ROENTGENOLOGICAL DETERMINATION OF PULMONARY TUBERCULOSIS.

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A ROENTGENOLOGICAL study of several thousand chests at Camp Lewis, Washington, has prompted certain definite conclusions which are set forth in this article. In the neighborhood of 600* cases of tuberculosis were studied by the roentgen staff. In approximately 300 cases the clinical and physical findings were recorded, and in the small percentage in which laboratory findings were positive that fact was noted.

Lack of time did not always allow of the most careful clinical study, but a sufficient number of each type were studied to permit correlation of physical findings with roentgen observations. Certain definite presentations on both plate and screen were positively proved to be tuberculous by the finding of the bacillus to make the diagnosis by roentgen study alone fairly sure in all types and stages.

The study was made by screen, single plate, stereoscopic plates and by combination of plate and screen. The most perfect plate and the most brilliant screen are absolutely essential. It is sometimes necessary to make many plates of a chest in order to bring out the definite characteristics, using different degrees of penetration and different angles and position of exposure. Single or even double screen plates or films do not present the necessary brilliant contrast and detail. The Coolidge tube will not make a diagnostic chest plate and the gas tube must be used.

In plate interpretation, every shadow, configuration and position must be understood and carefully studied. The visibility of the bronchovesicular tree must be appreciated for height, age, weight and occupation. The differentiation between peribronchial infiltration and thickening must be understood. The exact difference of degree of illumination and radiability is very important.

Abnormal configuration of the heart silhouette suggests valvular disease, which might account for abnormal lung shadows. Circumscribed areas resembling calcification are seen distributed throughout, particularly the lower quadrants, the result of dilated vessels in mitral disease.

Position and configuration of the diaphragm conveys much infor-

mation. The degree of parenchymal involvement is determined by the diaphragmatic position in deep inspiration. Previous pneumonias often leave pleurodiaphragmatic adhesions.

The condition of the hilus is extremely important. Infiltration, calcification or exaggeration results both from pulmonary infection and from abdominal infection, and the differentiation must be made from the general and minute lung picture.

The location of calcification areas throughout the lung fields is very suggestive. Diffused distribution suggests healed disseminated tuberculosis. A few areas in the lower quadrants designate the location of the primary tubercle, while those in the upper quadrants are more significant of quiescent, inactive or chronic active tuberculosis. The configuration and radiability of calcification areas suggest the activity of the process. Dense areas, undoubtedly lime salts, that are not discrete and where borders are not clear cut but blend gradually with the surrounding lung tissue, particularly if the center presents a delicate mottling (suggesting that the interstitial tissue remains intact), indicates that the process is active and the caseation area has not completely become calcified.

There are many pathological conditions which involve the lower quadrants but very few which involve the upper quadrants. If abnormal shadows are found in the upper quadrants the first thought is tuberculosis, although the pneumonias and various other conditions (which do not present the typical tubercular shadows) must be differentiated. If abnormal shadows are seen in the lower quadrants a non-tuberculous process is suspected.

Conclusions with explanation of modifications follows:

1. The definite determination of pulmonary tuberculosis by means of roentgen study alone in particularly every stage is possible. The stage and the activity of the process ar not as definitely established by roentgen study alone as by physical examination alone, but a combination of both is decidedly more reliable that either alone.

2. The stage of an excavation is readily determined.

3. There are distinct roentgenological pathognomonic indications of pulmonary tuberculosis.

4. The exact involvement is more readily made out by roentgen study. Much assistance is furnished the clinician in regard to prognosis.

The value of thorough roentgen study of the chest in tuberculosis varies slightly in different stages and forms of the disease.

1. In the incipient stage the roentgen study is of undoubted value, definite haziness, peribronchial infiltration and a marked degree of lessened illumination upon coughing or deep inspiration being determined on plate and screen. These roentgen indications appear as soon as does the clinical evidence.

In the cortical type the clinical findings are exaggerated while the roentgen evidence is not pronounced, but in the peribronchial

and bronchopneumonic tuberculosis the findings are reversed. In these latter types there is apparently a hilus tuberculosis and the infection extends bronchogenetically, usually along the course of the vertebral, first intercostal and second intercostal bronchi. Apparently the primary tubercle originates as follows: The bacilli are carried deep into the distal bronchiole by inspired air. The thin wall of the bronchiole offers little resistance to the infection and caseation and destruction take place. After calcification these areas are readily seen and are, for the most part, located in the lower quadrants (because of greater expansion and consequently the entrance of more air). The infection then extends along the lymphatics to the hilus, and if not arrested there proceeds peribronchogenetically to the apices, producing a peribronchial involvement in its incipiency. In practically every case of chronic tuberculosis the path of travel from the lower quadrants to the hilus and thence to the upper quadrant can be made out on the plate. Many chests have been observed in healthy subjects, in which the primary tubercle and the hilus calcification can be seen. Often the bronchi along which the lymphatic infection travels will show numerous small calcification areas, and a beaded appearance is presented. If the primary infection is in the abdomen no primary tubercle is found, but distinct hilus infiltration or calcification is observed. In massive hilus tuberculosis the infection must of necessity reach the bronchial glands by one of these two routes.

2. After fibrous infiltration takes place the roentgen indications are almost pathognomonic, particularly for the disease, but also for activity to a slightly lesser degree. Even before mediastinal retraction appears the evidence of fibrosis is apparent because of the extensive bronchovesicular thickening, the delicate strand-like shadows and the further decrease in radiability. After organization of the fibrous process, with more or less retraction and the appearance of compensatory emphysema, the diagnosis is more readily reached; but activity is less easily determined. At this stage the process is very liable to become quiescent. The physical findings are then very indefinite indeed.

3. The caseation areas are not definitely made out, but after calcification takes place, whether with marked or little fibrosis, the diagnosis is definite for tuberculosis and the degree of activity is suspected.

4. In the ulcerative type the excavations are classed as acute, subacute chronic and healed, and their age determined as follows:

(a) The acute cavity does not present a definite, distinct capsule; its configuration is not oval or circumscribed but more likely to be irregular; the radiability of its center is the same or less than the surrounding parenchymal shadows; it does not illuminate upon the patient coughing and there is no distinct drainage sinus leading toward the hilus.

(b) The subacute cavity begins to assume a definite circumscribed form; its capsule is readily seen, but is as yet not as definitely marked as in the chronic cavity; it usually contains a small quantity of fluid in its dependent portion, which indicates that drainage has not been perfected; above the fluid level the radiability is increased; indicating the presence of air. As yet the cavity does not illuminate upon coughing nor does the drainage sinus present as distinctly as later.

(c) The chronic cavity presents distinctly a fibrous capsule; it is oval or circular in shape, flat or spherical in configuration; it contains no fluid if the patient is examined late in the morning or in the afternoon; it illuminates brilliantly upon coughing and the thickened drainage sinus is readily made out.

(d) Healed cavities are not often seen; they present a very marked, thick capsule; contain no fluid; are very small in area and illuminate only slightly upon coughing. The drainage sinus is narrow, but its borders are very sharply outlined, indicating that no perisinus parenchymal involvement is present.

Differentiation between ulcerative excavations and the small emphysematous excavations must be made. These latter appear in the late fibrous stage and result from a constriction of the bronchioles from contraction of the fibrous tissue. The mechanics apparently is the same as in bronchiectasis, an increase of air pressure distal to the point of lumen-narrowing, which finally ruptures a terminal air sac and produces a small excavation. These excavations are multiple throughout the tuberculous area. No capsule is present; the outline is irregular; they illuminate upon coughing and contain no fluid in their uninfected stage. Clinically the isthmus is normal or widened; resonance is increased or normal; bronchovesicular breathing marked; harsh, prolonged expiration; and rales depending on the activity of the tubercular process. In all probability ulcerative cavities are often formed by infection of one or more of these emphysematous excavations. This has not been proved. In our experience only a small percentage of excavations were detected by physical examination even after being located by roentgen study. Probably the best indication of the existence of a cavity in the subacute and chronic stage, particularly after liquefaction of its contents, is a large amount of expectoration (2 to 4 ounces daily), in which the tubercle bacillus is demonstrated.

5. In the deep peribronchial type of tuberculosis, without parenchymal involvement, a distinct circumscribed peribronchial thickening will give way to an indication of peribronchial infiltration, and the bronchovesicular tree then presents a fuzzy rather than sharply delimited appearance. Extension of the process is then rapid, and there is an extreme lack of illumination on the plate, presenting a delicately mottled increase in density.

6. In massive hilus tuberculosis the roentgenologist is on a par with the clinician; its existence and activity can only be guessed.

Before calcification no definite indications are seen, either by screen or plate; after lime salt deposit, visualization of the area is obtained and quiescence suspected if the calcification is uniform in radiability and sharply demarcated, and *vice versa*.

7. In disseminated tuberculosis the lung picture presents nothing definite unless healing takes place, when many small areas of calcification are seen distributed throughout both lung fields, the greater number in the lower quadrants.

8. Probably all types of pulmonary tuberculosis can be classed, strictly speaking, as a true bronchopneumonia during a certain stage, but the roentgenological presentation of an acute tuberculous bronchopneumonia, in which the parenchymal involvement is peribronchial, superimposed upon a chronic fibrous process, is distinctive and typical. True, it is impossible by any means to differentiate the acute pneumonic process, especially if the tubercle bacillus is found in the sputum with an abundance of streptococcus, particularly the hemolytic type. Streptococcus infection of the lung parenchyma often involves the upper quadrants, both unilateral and bilateral, and is extremely difficult to distinguish from a tuberculous infection.

An old quiescent lesion which becomes active following measles, pneumonia, etc., is inclined to involve either both lungs in their entirety, the opposite lung only, especially in its lower quadrant, or the lower quadrant of the same lung in which the lesion is located.

PATHOGNOMONIC INDICATIONS. To the uninitiated there are two pathognomonic signs of pulmonary tuberculosis:

1. Lime-salt deposits in the upper quadrants, which do not necessarily indicate activity.

2. The cavity which indicates activity in the large percentage of cases.

Calcification areas, wherever located in the lung, in the vast majority of cases indicate that at some time there has been an active tuberculous process, but those of the lower quadrants are rather incidental, as healing usually takes place and the process stops at the bronchial glands. In the upper quadrants they indicate that the patient has a true, dangerous tuberculous infection which is either healed, quiescent or more or less active. If in addition there are indications of fibrosis, with no emphysema and little or no mediastinal or chest-wall retraction, activity is indicated. If clear, irregular emphysematous areas are interspersed, with more or less retraction, and the calcification areas are clear-cut and uniformly dense, the process is probably quiescent, chronic-inactive or healed. Differentiation from lues, the fungi infections and the pneumonias can be made without difficulty, but only after observing many cases.

Excavations are unmistakable if studied by both plates and screen. Activity is at once established, the differentiation from nontuberculous lung abscesses presenting no very great difficulty. The

tuberculous cavities, except in a very small percentage, are found high in the upper quadrants and are often multiple or bilateral, while lung abscesses are practically always found in the body of a lobe and seldom multiple or bilateral. In our series 4 cases presented tuberculous excavations in the lower lobes. Three cases of multiple pulmonary abscesses were detected in a series of over 2000 cases of pneumonia studied by roentgen rays. These abscesses were either filled with broken-down, semisolid tissue or with pus, the patients not living sufficient time for but few of them to establish drainage or air to collect above the fluid level. Lung abscesses invariably in a few days present a collection of air above the fluid level. The same is true of tuberculous cavities, but the surrounding lung shows unmistakable evidence of peribronchial thickening, fibrosis and other signs of tuberculosis, depending upon the stage of the process. A non-tuberculous cavity tends to heal if adequate drainage is established, and is seldom seen when empty, while the tuberculous cavity does not as often completely heal and is usually empty.

Other conditions to a lesser degree pathognomonic are as follows: Fibrosis, retraction of the trachea, mediastinal contents, heart and chest wall, a decided lack of illumination of one or both upper quadrants on deep inspiration or coughing before the screen, and a lessened radiability, either uniform or delicately mottled on the plate; abnormal presentation in the upper quadrants if there is a hanging "dropped" or very small heart silhouette; or if the diaphragm on the corresponding side is in partial expiratory position or its excursion is impaired on deep inspiration. Any abnormality found in the upper quadrants should prompt the roentgenologist to suggest the probability of tuberculosis unless definite indications of another process are certain.

An interesting phenomenon seen in the more chronic emaciated cases is the difference in radiability of the pectoralis muscles, those on the affected side not being so dense and distinct.

In regard to the extent of the process and the prognosis much assistance is furnished the internist. Only a small percentage of cavities are diagnosed by the internist unless he be particularly adept. The size of the cavity and its stage can hardly be estimated without the roentgen rays. Chronic-inactive types present few physical signs, but the process in its fullest extent is visualized by both screen and plate. In the incipient stage, certain physical signs, rales and breath-sound changes are often more definite than the extent of the process would indicate.

The roentgen study is indispensable in treatment by artificial pneumothorax. Adhesions between the visceral and parietal pleura defeat the object, preventing compression of the diseased area. These adhesions will often be separated by more pressure. The roentgen study indicates when lung collapse goes on to lung compression and the amount of pressure necessary to separate the adhesions.